

ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 37

TROUBLESHOOTING EXPERIMENTS I



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Experiment Lesson 37

INTRODUCTION

This lesson is the first of a series of troubleshooting experiment lessons designed to give you practical experience in troubleshooting. Troubleshooting means actually finding the defective component. Once you find the trouble, the actual replacement of most defective parts in a radio receiver is easy and takes but a few minutes.

In order to perfect rapid troubleshooting procedures, first you must acquaint yourself with the normal voltages that exist at key points in the typical radio receiver. Then, by introducing troubles one at a time into the receiver, you will learn what changes these troubles cause in the normal voltages, and what these troubles do to the normal sound coming out of the loud speaker. Once you know what particular changes are caused by particular troubles in the receiver, you will be able to locate these troubles.

The troubleshooting work will be done on the receiver you have built. This receiver is in some respects more complex than many commercial radio receivers. It can serve to illustrate many servicing problems. But the possible number of problems is so great that it is not possible to demonstrate all the ways to deal with troubles that could possibly occur, even in the simpler receivers. The way to prepare yourself to solve any servicing problem is to learn the correct approach to it. These servicing lessons, by showing you how actual problems are solved, will help you develop the correct approach.

Many tests will be introduced in these lessons, but neither the reasons for the tests nor the theory involved will be explained. Keep all your lesson material in good order so that you can return to your Theory Lessons and Service Practices

booklets when you are not clear about the theory involved.

Furthermore, in these troubleshooting lessons, you will not get specific instructions on how to set up your meter for various measurements. By this time, you should have learned to set up your meter. You now must get into the habit of correctly setting up your meter before each measurement in order to protect your meter from damage. Before making any measurement always see that the FUNCTION switch is properly set to DC, AC, or OHMS, depending on what you are measuring.

Warning: Never connect the meter leads across any voltage source when the FUNCTION switch is set to OHMS, or when the meter RANGE switch is set to one of its current positions. Failure to observe this rule may cause one or more shunts to be burned out, or it may cause your meter movement to be damaged.

Before making any measurement and after setting the FUNCTION switch properly, estimate the amount of voltage at the point in the circuit to which you are going to connect the meter leads, both to protect your meter and for efficient servicing. If you have no idea what voltage to expect at a certain point in the circuit, what good will it do you to measure the voltage? So, take a moment to estimate what voltage should be present and set the RANGE switch to a high enough range for this voltage. If you have any doubt as to the amount of voltage present, always set the RANGE switch to the highest scale on the meter.

Whenever you want to measure the a-c component at a point in the circuit containing both a-c and d-c voltages, use the OUTPUT meter connection. Furthermore,

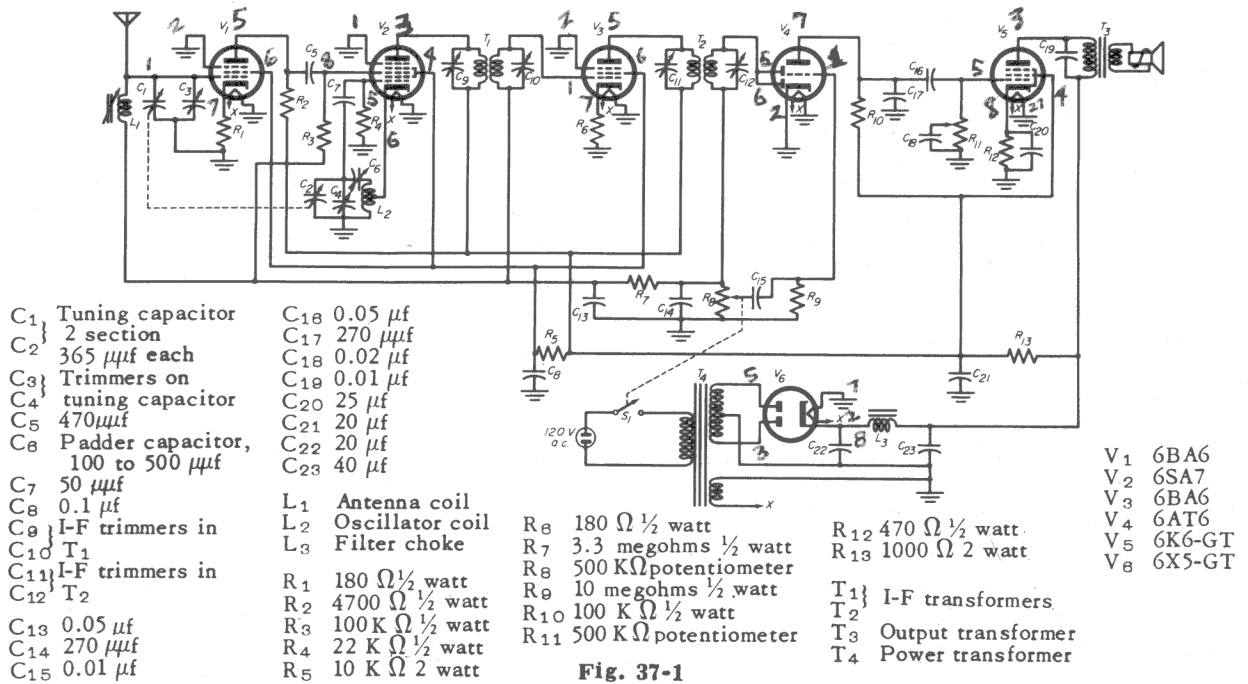


Fig. 37-1

after you have finished making a series of measurements, or are finished using your meter for the time being, don't just leave the RANGE switch anywhere but return it to the highest voltage position, and set the function switch to DC. This will prevent damage to your meter if you start using it again later and forget to check the positions of the switches.

Caution: The voltages encountered in even a small radio receiver may be dangerous. Work carefully. Never use more than one hand at a time when testing a live receiver, and don't let your hand or body touch any part of the wiring or chassis.

In order to perform these troubleshooting experiments, it will be necessary to unsolder and resolder many connections many times. You may not like to do this, especially if you have carefully wired their receiver, paying attention to the neatness and good appearance of the wiring underneath the chassis. However, remember that the primary purpose of your chassis is to give you practical experience in building electronic equipment, locating defective components, and replacing them.

This experiment lesson deals with the troubleshooting of the power-supply section of the receiver. The complete schematic of your receiver is shown in Fig. 37-1. The schematic of the power-supply portion of

your receiver is shown in Fig. 37-2. The functions of this section of the receiver are as follows:

1. To provide filament power at the correct voltage and current for all the tubes in the receiver.
2. To provide d-c operating voltages, free from any a-c ripple, for the plates and screens of the various tubes in the receiver.

The defects that can occur in the power supply section of the receiver are as follows:

1. Low or no B+ voltages for the tubes. Low B+ will reduce the sensitivity, gain, and output volume of the receiver.
2. Low or no filament voltage for the tubes. This will cause the receiver to be

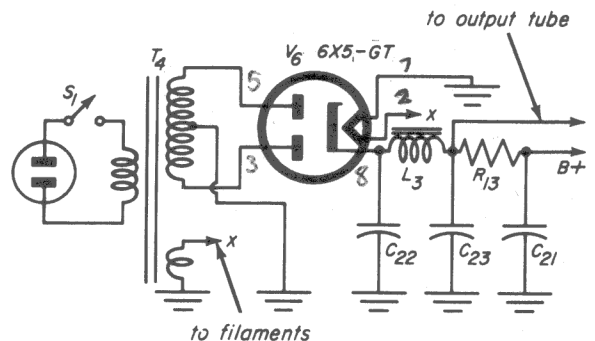


Fig. 37-2

completely dead, or have reduced sensitivity, gain and output volume.

3. Excessive amount of a-c ripple in the B+ voltage for the tubes. This will cause an excessive amount of audible hum in the loudspeaker.

EXPERIMENT 37-1

To learn the normal indications and the normal resistances and voltages in a properly operating power supply.

Procedure.

Step 1. With the receiver line cord disconnected, make and record the resistance measurements, in Table A, using the appropriate ohmmeter scale.

Step 2. Plug in the receiver line cord, and turn on the receiver.

Warning: Observe whether all the tubes are lit. Disconnect the power from the set

TABLE A	
Measurement	Resistance (ohms)
Across line-cord plug — switch off	∞
Across line-cord plug — switch on	8.6
One side of line-cord plug to chassis	∞
Other side of line-cord plug to chassis	∞
One rectifier plate to chassis	230
Other rectifier plate to chassis	240
Rectifier plate to plate	480
Rectifier cathode to ground	* ∞
Across filament winding	1

if, while waiting for the tubes to warm up, any of the following conditions occur:

1. The rectifier tube plates start to glow red.

2. There is a purplish glow near the rectifier plate.

3. There are any signs of overheating, such as smoke, melted wax, or pitch coming out of transformer cases, burning odor, or discoloration of resistors.

Step 3. Turn the volume control down to minimum. Note how close you must place your ear to the loudspeaker in order to hear the hum. If you have to get quite close to the loudspeaker before the hum is heard, you can consider the hum level to be satisfactory.

Step 4. Measure and record the voltages called for in Table B.

TABLE B	
Measurement	Voltage (volts)
A-C line voltage	127
A-C input to each rectifier plate	244 244
A-C input to the rectifier filaments	6.3
A-C input to other filaments	6.3
D-C output at the rectifier cathode	260

Step 5. Set up your meter as an output meter on the lowest a-c range. Measure the amount of a-c voltage present at the various points called for in Table C.

Discussion. Typical resistance and voltage measurements as called for in the experiment above are shown in the schematic diagram of Fig. 37-3. These are typical

voltage measurements that should be obtained on your receiver.

TABLE C	
Measurement	Voltage (volts a.c.)
Cathode of the rectifier tube	1.8
Junction of filter choke and second filter capacitor	0

The voltages that might be encountered in other receivers of this type are shown in Table D.

In this receiver, the required voltage for the rectifier filament is the same as the filament voltage for the other tubes in the receiver. However, in many other receivers the rectifier tube has a 5-volt filament, whereas the other tubes have 6-volt filaments. In such cases, the power transformer has a separate rectifier filament winding.

EXPERIMENT 37-2

To learn the abnormal indications and

voltage changes caused by several common power-supply defects.

TABLE D	
Measurement	Voltage
A-C input to the rectifier plates (measured from each plate of the rectifier to ground)	200 to 375 volts a.c.
D-C output at the rectifier cathode	225 to 400 volts d.c.
Rectifier filaments	5 or 6 volts a.c.
All other tube filaments	6 volts a.c.

Procedure.

Step 1. Disconnect one of the high-voltage secondary leads of the power transformer from one of the rectifier-tube plates.

Step 2. Make measurements and record them as called for in Table E.

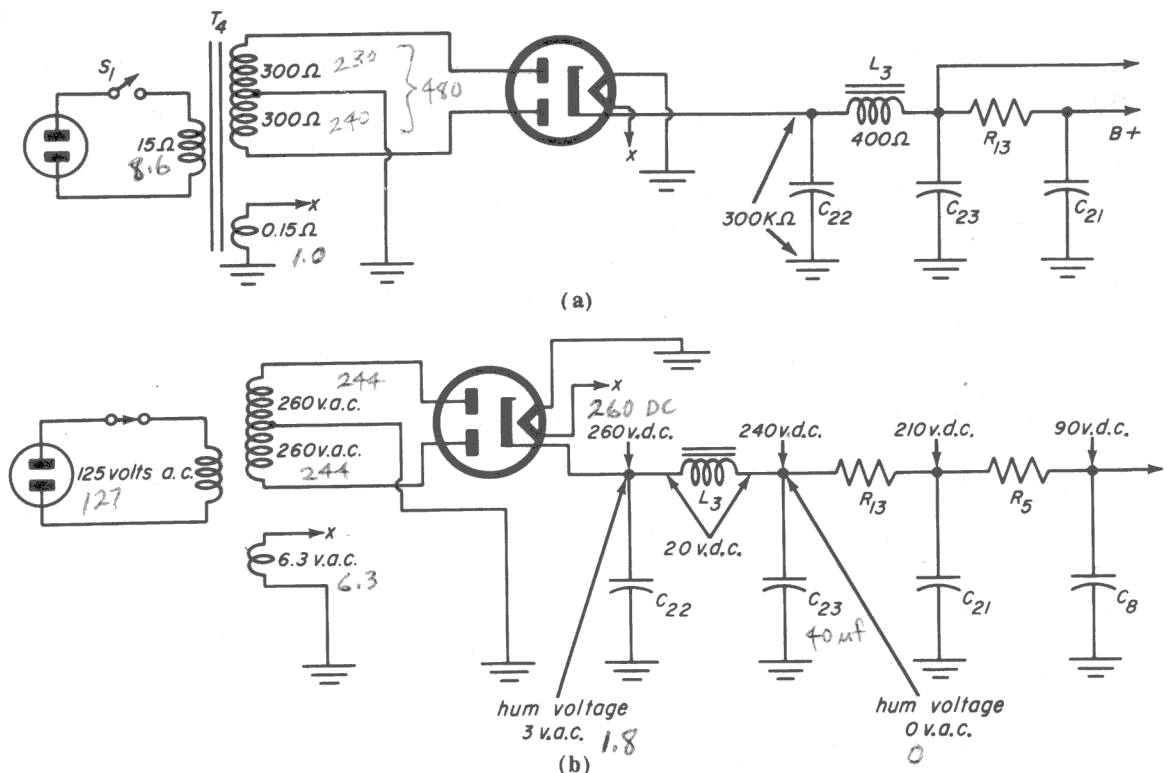


Fig. 37-3

TABLE E	
Measurement	Voltage (volts)
A-C input between pin 3 ^{RECT PLATE} and ground	230 vac
A-C input between pin 5 ^{RECT PLATE} and ground	0
D-C output from pin 8 ^{CATHODE} to ground	230 vdc
A-C hum (use output meter) from pin 8 ^{CATHODE} to ground	2.8 vac

Is the loudspeaker hum at minimum volume increased or decreased? **NO**

Discussion. Disconnecting one of the secondary leads simulates either an open circuit in one half of the high voltage secondary winding or a defective section in a full-wave rectifier tube. This defect turns the full-wave rectifier into a half-wave rectifier. As a result, the B+ voltages are reduced; the a-c ripple voltages in the d-c output are increased. However, the hum heard in the loudspeaker may actually decrease. The frequency of the hum voltage is now 60 cps instead of 120 cps, and the small speaker may not respond to it as well. This trouble is usually due to an open circuit in one half the secondary winding, and it can be localized to the transformer by resistance measurements of each half of the winding.

EXPERIMENT 37-3

To observe the effect of a shorted filter choke.

Information. Although filter chokes rarely short, this defect occasionally does happen, and you should know what abnormal indications are produced.

Procedure.

Step 1. Short out the filter choke with a clip lead or a short piece of wire.

Step 2. Note whether there is any change in the hum level as heard in the loud speaker. Record your observation here.

No increase

Step 3. Measure the a-c ripple voltage at the 40- μ f (semicircle) section of the electrolytic capacitor and record it here:

1.5 vac
volts a.c.

How does this compare with the normal a-c ripple voltage that should be present at this point?

Discussion. With the filter choke shorted out, there is no noticeable increase in the hum level as heard in the loudspeaker in this receiver because of the large filter capacitors in the filter section. With smaller filter capacitors, a greater increase in hum would be heard. The a-c ripple at the 40- μ f (semicircle) section of the electrolytic capacitor increases from zero to about 1.5 volts.

EXPERIMENT 37-4

To learn the abnormal indications produced by defective filter capacitors.

Procedure.

Step 1. Disconnect all the leads from the 20- μ f (square) section of the electrolytic capacitor. Make sure that all the leads that were connected to this terminal remain connected together. Measure and record the voltages called for in Table F.

How do these voltages compare with the normal voltages?

Step 2. Reconnect the 20- μ f filter capacitor into the circuit, making sure that all the connections that were removed are reconnected.

Step 3. Disconnect all the leads from the

TABLE F	
Measurement	Voltage (volts)
D-C output voltage at this junction	
D-C output voltage at the second filter capacitor	
A-C ripple voltage at this junction	
A-C ripple at the second filter capacitor	

second (40- μ f) section of the electrolytic capacitor. Make sure that all the leads that were connected to this terminal remain connected together. Measure and record the voltages indicated in Table G.

How do these voltages compare with the normal voltages?

TABLE G	
Measurement	Voltage (volts)
D-C output voltage at this junction	
A-C ripple voltage at this junction	
D-C output voltage at the second filter capacitor	
A-C ripple at the second filter capacitor	

Step 4. Replace all the leads at the second section of the electrolytic capacitor, making sure that all the connections that were removed are reconnected.

Step 5. Disconnect all the leads from the third triangle section of the electrolytic capacitor. Make sure that all the leads that were connected to this terminal remain connected together. Measure and record the voltages indicated in Table H.

TABLE H	
Measurement	Voltage (volts)
D-C output voltage at this junction	
A-C ripple voltage at this junction	
D-C output voltage at the second filter capacitor	
A-C ripple at the second filter capacitor	

How do these voltages compare with the normal voltage?

Discussion. Removal of the input filter capacitor causes a decrease in the d-c output voltage to about 200 volts and an increase in the a-c ripple to about 100 volts. However, there is little or no increase in the hum heard in the loudspeaker because of the remaining filter capacitors.

EXPERIMENT 37-5

To study a method of tracing B+ shorts in a receiver using a series protective lamp.

Information. Many times a B+ short that develops in a receiver can be found most readily when a-c power is applied to the receiver and the operating voltages are allowed to develop. But if this is done, the short in the receiver may cause excess current to flow and damage the rectifier tube, the power transformer, or some other component in the receiver. Sometimes, the B+ short will cause fuses to blow. It is embarrassing when this happens in the customer's home. By the use of a series protective lamp, fuse blowing will be prevented and further damage to the receiver will be minimized. If a receiver is connected to the a-c power through a series incandescent lamp as shown in Fig. 37-4, all the current taken by the receiver must pass through the lamp. If a 40-watt lamp is used, the amount of current taken by a properly operating small receiver will be just

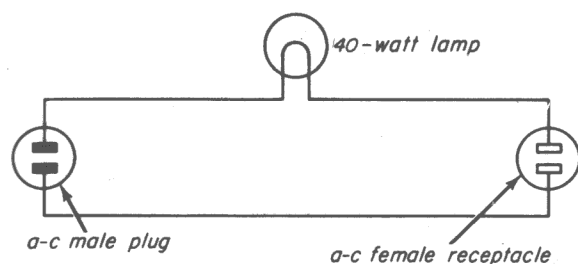


Fig. 37-4

enough to cause the lamp to glow faintly. Since the lamp limits the current through the receiver to a safe value, the receiver can be connected to the a-c line, even though there is a short in it. The short will be indicated by the lamp lighting to almost its full brilliance. Then various circuits can be disconnected one at a time. As soon as the defective circuit has been disconnected, the brilliance will drop to a faint glow.

Procedure.

Step 1. Prepare a simple protective lamp circuit such as the one shown in Fig. 37-4.

Step 2. Remove the 6X5-GT and 6K6-GT tubes from your receiver.

Step 3. Connect the receiver to an a-c outlet through the protective lamp.

Step 4. Turn on the receiver and record whether the lamp is bright or faint. _____

Step 5. Replace the 6K6-GT tube, and record whether the brilliance of the lamp is bright or faint as the tube warms up. _____

Step 6. Replace the 6X5-GT tube, and record whether the brilliance of the lamp is bright or faint. _____

After this tube warms up, record whether the brilliance of the lamp is bright or faint. _____

Step 7. Disconnect the receiver from the a-c line. Connect your cliplead across lugs

1 and 2 of TS-A to simulate a direct short in the receiver across the a-c line.

Step 8. Connect the receiver through the protective lamp to an a-c outlet, and record whether the brilliance of the of the lamp is bright or faint. _____

Why doesn't a fuse blow? _____

Step 9. Disconnect the receiver and remove the clip lead.

Step 10. Using a thin screwdriver having a well-insulated handle, momentarily short pin 2 of the 6X5-GT tube socket to ground. Note how the brilliance of the lamp changes and record it here. _____

How does the brilliance of the lamp compare to its full brilliance? _____

Step 11. Using the insulated-handle screwdriver, short first pin 3 and then pin 5 of the 6X5-GT tube socket to chassis.

What effect does this have on the brilliance of the lamp? _____

Step 12. Using the insulated-handle screwdriver, short the 40- μ f terminal of the electrolytic capacitor to chassis.

What happens to the brilliance of the lamp? _____

Why? _____

Discussion. This experiment shows how shorts in the receiver in either the transformer windings or the external circuits show up as increased brilliance of the series protective lamp due to increased current flow through this lamp because of the short.

When a 40-watt lamp is used, the following results are obtained:

With the 6X5-GT and 6K6-GT tubes out of the receiver, very little current flows in the secondary circuit of the power transformer; hence, almost no current flows in the primary winding. The series lamp does not light up at all. The additional filament current that is drawn when the 6K6-GT tube is replaced causes a very faint dull glow in the lamp. However, if at this point the filament winding is shorted to ground, or one-half of the secondary winding is shorted to ground, the lamp will light up to its full brilliance, indicating the presence of the short. A single shorted turn within any of the transformer windings will also cause the lamp to light up to its full brilliance. Since such a shorted turn usually cannot be detected by resistance measurements, yet makes the transformer defective, the series-lamp test is very useful in this case.

When the 6X5-GT is inserted, the dull red glow immediately becomes somewhat brighter, due to the increased filament current drawn by this tube. As soon as the rectifier heats up, and B+ current starts to flow, the brilliance of the lamp will increase to about 30 percent of its full brightness, or a dull orange glow. This is the normal brightness for a 40-watt lamp in series with a properly operating 6-tube receiver of this type.

The effect of B+ shorts is to cause a considerable increase in the brilliance of the lamp. Since the lamp limits the current, damage due to the short is prevented. This is very useful when you are replacing a burnt out rectifier tube. There is always the possibility that the rectifier tube was burnt out due to a shorted filter capacitor. Using the series lamp minimizes the danger of the new rectifier being burnt out if the short is still present.

It should also be noted that the receiver functions quite well even though the a-c voltage input to it is reduced by the voltage drop across the lamp. This would not be the case if the rectifier tube were weak. Seeing if the receiver will operate in series with the lamp gives a rough indication of the condition of the rectifier tube.

EXPERIMENT 37-5

To study how an open circuit may be detected with a voltmeter.

Procedure.

Step 1. Measure the a-c line voltage at the a-c outlet, and record your reading here:

volts a.c.

Step 2. Plug the receiver line cord into the a-c outlet.

Step 3. Turn the receiver power switch on and measure the a-c voltage across the switch terminals. Record your reading here:

volts a.c.

Step 4. Turn off the receiver power switch, but leave the line cord connected to the a-c outlet. Measure the a-c voltage across the switch terminals and record it here:

volts a.c.

How does this voltage compare with the voltage measured in Step 3?

Step 5. Disconnect the line cord of the receiver.

Discussion. This experiment demonstrates that the full line voltage always appears across a break in a circuit. The reason for this is shown in Fig. 37-5. When

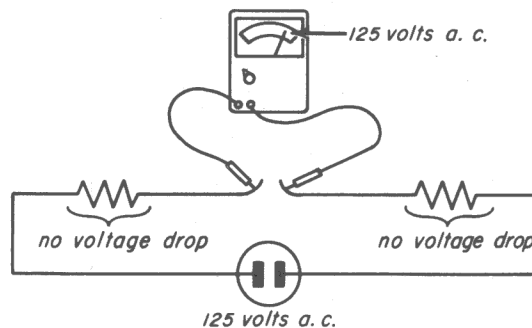


Fig. 37-5

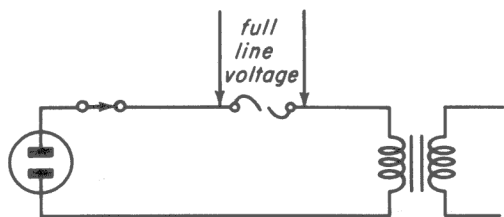


Fig. 37-6

the voltmeter is connected across the break in the circuit. the voltmeter completes the circuit. However, because of the high resistance of the meter, it draws a negligible amount of current. Therefore, there is no noticeable voltage drop across any part of the circuit, and the full line voltage appears across the voltmeter terminals. Thus, when a fuse is placed in series with some device to protect it, as shown in Fig. 37-6, and the fuse opens, the full line voltage will appear across the fuse terminals. For this reason, always use

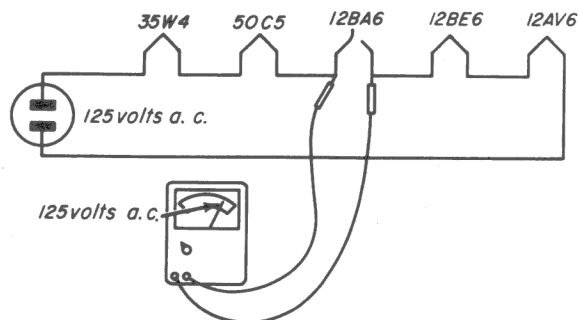


Fig. 37-7

caution when removing burnt out fuses. When a tube filament opens up in the series filament circuit of an a-c/d-c receiver, the tube having the open filament can be quickly located by touching the voltmeter leads across the filament pins of each tube, as shown in Fig. 37-7. The full line voltage will appear across the filament that is burnt out.